Seismic & Wind Analysis and Design of High Rise Building in Different Seismic Zones

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Abstract—Recent earthquakes in India show that not only non-engineered but also engineered buildings in our country are susceptible even to moderate earthquakes. Indian Standard IS 1893 is revised in 2002. A number of buildings those were designed as per the previous code may not comply with the present code. Therefore evaluating seismic performance of a building and proposing suitable retrofit measure is an important area of study in this context. In the present study an attempt has been made to evaluate an building located in two different zones (seismic zone III & IV) using equivalent static analysis. Indian Standard IS-1893:2002 (Part-1) is followed for the equivalent static analysis procedure. Building is modeled in commercial software STAAD Pro. Seismic force demand for each individual member is calculated for the design base shear as required by IS-1893:2002. Corresponding member capacity is calculated as per Indian Standard IS456:2000. Deficient members are identified through demand-to-capacity ratio. We considered the residential building of G+ 15 storied structure model for the seismic analysis located in zone III & IV. The total structure was analyzed by computer with using STAAD.PRO software. We observed the response reduction of cases ordinary moment resisting frame and special moment resisting frame values with deflection diagrams in static and dynamic analysis.

Key words: Wind Analysis & Design of High Rise Building, Different Seismic Zones

I. INTRODUCTION

Structural analysis comprises the set of physical laws and mathematics required to study and predicts the behavior of structures. Structural analysis can be viewed more abstractly as a method to drive the engineering design process or prove the soundness of a design without a dependence on directly testing it. To perform an accurate analysis a structural engineer must determine such information as structural loads, geometry, support conditions, and materials properties. The results of such an analysis typically include support reactions, stresses and displacements. This information is then compared to criteria that indicate the conditions of failure. Advanced structural analysis may examine dynamic response, stability and non-linear behavior.

The aim of design is the achievement of an acceptable probability that structures being designed will perform satisfactorily during their intended life. With an appropriate degree of safety, they should sustain all the loads and deformations of normal construction and use and have adequate durability and adequate resistance to the effects of seismic and wind. Structure and structural elements shall normally be designed by Limit State Method. Account should be taken of accepted theories, experiment and experience and the need to design for durability.
III. EARTHQUAKE WAVES

Elastic rebound produces waves from the point of rupture. The rupture may be localized at a point, along a slip line or a slip surface. Earthquake waves have clearly identifiable components. They are Primary wave (refractory), Secondary or shear wave (transverse), Raleigh wave (refractory) and Love wave (transverse). Figure of these waves are given in figure 3.

![Elastic rebound produces waves from the point of rupture.](image)

Table 1: Specification for Design of Building for Zone 3 & 4

<table>
<thead>
<tr>
<th>Specification For Design of Building: (Case I) Zone 3</th>
<th>Specification For Design of Building: (Case II) Zone 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) All columns = 0.6 x 0.6 m</td>
<td>1) All columns = 0.6 x 0.75 m</td>
</tr>
<tr>
<td>2) All beams = 0.5 x 0.3 m</td>
<td>2) All beams = 0.6 x 0.3 m</td>
</tr>
<tr>
<td>3) Parapet = 0.115 m wall.</td>
<td>3) Parapet = 0.115 m wall.</td>
</tr>
<tr>
<td>Live load on the floors is 4 KN/m²</td>
<td>Live load on the floors is 4 KN/m²</td>
</tr>
<tr>
<td>Grade of concrete and steel used:</td>
<td>Grade of concrete and steel used:</td>
</tr>
<tr>
<td>Used M25 concrete and Fe 500 steel for main</td>
<td>Used M25 concrete and Fe 500 steel for main</td>
</tr>
<tr>
<td>&amp; Fe 415 for secondary.</td>
<td>&amp; Fe 415 for secondary.</td>
</tr>
<tr>
<td>Materials for the Structure:</td>
<td>Materials for the Structure:</td>
</tr>
<tr>
<td>The materials for the structure were specified as</td>
<td>The materials for the structure were specified as</td>
</tr>
<tr>
<td>concrete with their various constants as per standard</td>
<td>concrete with their various constants as per standard</td>
</tr>
<tr>
<td>Zone factor,</td>
<td>Zone factor,</td>
</tr>
<tr>
<td>Z (For zone III) = 0.16 Importance factor, I = 1</td>
<td>Z (For zone IV) = 0.24 Importance factor, I = 1</td>
</tr>
<tr>
<td>Response reduction factor, R = 3 Method: Seismic</td>
<td>Response reduction factor, R = 3 Method: Seismic</td>
</tr>
<tr>
<td>Coefficient Method</td>
<td>Coefficient Method</td>
</tr>
<tr>
<td>Type of soil = Medium</td>
<td>Type of soil = Medium</td>
</tr>
</tbody>
</table>

However, for seismic analysis, following data has been used as per IS 1893 Part I-2002 [4].

1) Load Combination for Earthquake Load
   - 1.5(DL+LL)
   - 1.2(DL+LL±EQ)
   - 1.5(DL±EQ)
   - 0.9DL±1.5EQ

Loading consideration Loads acting on the structure are dead load (DL), Live Load (LL) and Earthquake Load (EL).
   - DL: Self weight of the structure, Floor load and Wall loads
   - LL: Live load 4KN/sq. m is considered
   - SL: Zone: III
   - Soil type: II
   - Response reduction factor: 5
   - Importance factor: 1
   - Damping: 5%

2) Seismic weight of building:
The seismic weight of the building means is calculated on the entire floors weight of the building Fundamental Natural period as per IS 1893(part1):2002 1. The approximate fundamental natural period of vibration (T_a) in seconds of a moment resisting frame building without brick infill panels may be estimated by the empirical expression
   \[ T_a = 0.075h^{0.75} \text{ for RC framed building} \]
   \[ T_a = 0.075h^{0.75} \text{ for steel framed building} \]
Lump mass has been calculated considering pin joint at all nodes of model.

3) Calculation of Wind Loads for both cases
Wind loads are calculated as per IS 875 Part II (1987)
For the Present work, the basic wind speed (V_b) is assumed as 44m/s and the building is considered to be open terrain with well scattered obstructions having height less than 10m with maximum dimension more than 50m and accordingly factors K1, K2, K3 have been calculated as per IS 875 Part II (1987).
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![Image](https://www.ijsrd.com/issue/07/2016/issue07_2016_020.jpg)

**Fig. 4: Wind load**

Terrain Category- 2, Class- B  
K1- Probability factor- 1.07  
K2- Terrain, height and size factor- 1.15  
K3- Topography factor- 1  
Design wind speed, \( V_z = V_b (K_1 \times K_2 \times K_3) \) (3)  
\( V_z = 2931.35 \text{ Kg/m}^2 \)  
Design pressure, \( P = 0.6 \times V_z^2 \) (4)  
\( = 1758 = 1.7 \text{ KN/m}^2 \)

**CASE 1: EARTHQUAKE LOADS +X DIRECTION**

TIME PERIOD FOR X 1893 LOADING = 2.00000 SEC  
SA/G PER 1893= 0.680, LOAD FACTOR= 1.000  
FACTOR V PER 1893 AT GL= 0.0163 X 89974.01  
FACTOR V PER 1893 AT 30 M= 0.0082 X 89974.01  
FACTOR V PER 1893= 0.0158 X 89974.01

**CASE 2: EARTHQUAKE LOADS +X DIRECTION**

TIME PERIOD FOR X 1893 LOADING = 1.35915 SEC  
SA/G PER 1893= 0.736, LOAD FACTOR= 1.000  
FACTOR V PER 1893= 0.0177 X 72879.35

**EARTHQUAKE LOADS +Z DIRECTION**

TIME PERIOD FOR Z 1893 LOADING = 1.35915 SEC  
SA/G PER 1893= 1.001, LOAD FACTOR= 1.000  
FACTOR V PER 1893 AT GL= 0.0240 X 89974.01  
FACTOR V PER 1893 AT 30 M= 0.0120 X 89974.01  
FACTOR V PER 1893= 0.0232 X 89974.01

**Table 2: Earthquake Loads**

<table>
<thead>
<tr>
<th>Case</th>
<th>Load Direction</th>
<th>Time Period</th>
<th>S/G Factor</th>
<th>Load Factor</th>
<th>Factor V at GL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>X</td>
<td>2.00000</td>
<td>0.680</td>
<td>1.000</td>
<td>0.0158</td>
</tr>
<tr>
<td>2</td>
<td>X</td>
<td>1.35915</td>
<td>0.736</td>
<td>1.000</td>
<td>0.0177</td>
</tr>
<tr>
<td></td>
<td>Z</td>
<td>1.35915</td>
<td>1.001</td>
<td>1.000</td>
<td>0.0232</td>
</tr>
</tbody>
</table>

**Fig. 5: Node Displacement Summary**

**Fig. 6: Beam Displacement Detail Summary**

**Fig. 7: Node Displacement Summary**

**Fig. 8: Beam Displacement Detail Summary**

**Fig. 9: Maximum Node Displacement**

**IV. GRAPHICAL RESULT OF ANALYSIS WITH COMPARISON OF DIFFERENT PARAMETERS & CONCLUSION**

**A. Maximum Node Displacement**

- Maximum nodal displacement has been found in model zone III in x, y, z direction which also having less sizes of beams and columns than model in zone IV.
- Impact of vibrations during earthquake in case of displacement displace nodes in particular direction more in zone III,
- Hence more ductile reinforcement needed in such area as per design.
Maximum beam displacement has been found in model zone III in x, y, z direction which also having less sizes of beams and columns than model in zone IV.

- Maximum relative displacement found as per software analysis is 109.375mm.
- Impact of vibrations during earthquake in case of displacement displace nodes in particular direction more in zone III,
- Hence more ductile reinforcement needed in such area as per design

- Maximum axial force in x direction, and shear in y & z direction has been found in model zone III which also having less sizes of beams and columns than model in zone IV.

- Maximum bending moment has been observed in My and Mz direction in Zone III, as shown in graph.

- Weight of the building above cracking is the shear force that broke the building.
- Max effect of damage occurs at base of building.
- To resist the extra loads while combinations during EQ we need to provide ductile reinforcement at joints specially, as per the IS 13920: 1993 for output result.
- We can also provide shear wall where chances of concentration of loads is max during EQ like lift duct etc.
- Base shear is more or less of the same magnitude irrespective of change in configuration of the building if we analysis by response spectrum method.
- In column there is very little change in axial force due to gravity load in comparison with earthquake load. The axial force is linearly varies along with the storey height.
- The bending moment due to earthquake load in column and in footing is highly increasing with the storey height. So, if earthquake load is not considered for the analysis, there will be possibilities of overturning.
- The earthquake force produces the lateral displacement in the structure, so the displacement due to earthquake load is very severe.

REFERENCES
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